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REGIONAL COST ESTIMATES FOR REHABILITATION AND MAINTENANCE PRACTICES ON ARMY TRAINING LANDS

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REGIONAL COST ESTIMATES FOR REHABILITATION AND MAINTENANCE PRACTICES ON ARMY TRAINING LANDS

1. Purpose. This Public Works Technical Bulletin (PWTB) transmits the current, regional cost data obtained from various Federal, State, and private agencies concerning land rehabilitation and maintenance (LRAM) practices.

2. Applicability. This PWTB applies to all continental U.S. Army facilities.

3. References.

a. Army Regulation (AR) 200-3, “Environmental Quality, Natural Resources–Land, Forest and Wildlife Management,” 28 February 1995, as modified 20 March 2000.

b. Additional references are in Appendices E and F.

4. Discussion.

a. The U.S. Army is responsible for managing millions of acres of land used to support a variety of training and testing activities. Increased use of this land results in deterioration that can adversely affect mission requirements and safety. Various LRAM practices can offset this deterioration by physically or biologically controlling erosion and stabilizing land surfaces with vegetation. These practices frequently include the use of heavy equipment and farming implements to manipulate site characteristics, install erosion control materials and structures, prepare seedbeds, apply soil amendments, and seed or transplant vegetation. Planning, designing, budgeting, and implementing comprehensive LRAM projects requires information concerning component costs associated with erosion control and revegetation.

Differences in climate, geology, soils, and vegetation types between Army installations, however, result in significant cost variability.

b. This report summarizes current, regional cost data obtained from various Federal, State, and private agencies concerning LRAM practices. In general, LRAM costs were highest in the Pacific Coast, Intermountain, and Northeast regions of the United States and lowest in the Great Plains, Central Lake, and Humid South regions. This finding reflects regional differences in costs of goods and services, proximity to larger cities capable of providing necessary LRAM equipment and services, and proximity to production agriculture enterprises.

c. Appendix A contains background information.

d. Appendix B contains project details and data collection information.

e. Appendix C contains types of maintenance and rehabilitation activities.

f. Appendix D contains summary information.

g. Appendix E contains general references.

h. Appendix F contains references for cost data sources.

i. Appendix G contains approximate retail prices of common herbicides.

5. Points of Contact. HQUSACE is the proponent for this document. The POC at HQUSACE is Mr. Malcolm E. McLeod, CEMP-II, 202-761-0632, or e-mail: malcolm.e.mcleod@usace.army.mil.

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APPENDIX A

INTRODUCTION

The U.S. Army is responsible for managing about 12.4 million acres of land used to support a variety of military training and testing activities (U.S. Department of the Army 1989). This land base, however, is considered inadequate for meeting existing training mission requirements (U.S. Department of the Army 1978). Increased use of this limited land resource in recent years has resulted in a gradual deterioration in the condition of natural resources assets at Army training facilities within the United States (Diersing and Severinghaus 1984; Goran et al. 1983; Johnson 1982).

To offset the deterioration caused by military training and testing activities, installation land managers rely on various rehabilitation and maintenance practices to maintain or reestablish the ecological integrity and stability of training lands. These practices frequently include the use of heavy equipment and farming implements to manipulate site characteristics, install erosion control materials and structures, prepare seedbeds, apply soil amendments, and seed or transplant vegetation. Planning, designing, and implementing comprehensive land rehabilitation and maintenance projects requires information concerning associated component costs (e.g., earthwork, sediment fence, tillage, fertilizer application, seeding, etc.). Significant differences between Army installations in climate, geology, soils, vegetation types, mission requirements, and proximity to large population centers, however, means that the cost (e.g., for seedbed preparation, fertilizing, and revegetating damaged training areas) will vary widely.

Because of the variability in land rehabilitation and maintenance (LRAM) costs between installations located in the United States, Headquarters, U.S. Army Corps of Engineers (HQUSACE), asked the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) to coordinate the assembly of regional cost data for use by installation land managers.

In addition to providing regionally specific cost data essential for budgeting, planning, and designing LRAM projects, these data are also useful for selecting the most appropriate practice based on relative costs and desired results. For example, the cost of drilling grass seed might be 1.5 times greater than the cost of broadcasting seed, but improved germination and establishment of drilled seed compared to broadcasted seed compensates for the difference in cost, especially on highly erosive sites requiring immediate vegetative stabilization. Although actual costs for rehabilitation and maintenance practices will undoubtedly change and require update over time, relative costs between practices should remain somewhat constant, ensuring their applicability well into the future. In response to the request by HQUSACE, ERDC/CERL began to assemble regional cost estimates pertaining to the component activities associated with LRAM practices.

The objective of this report is to provide current, regionally based cost estimates for the component activities associated with land rehabilitation and maintenance. The first task in this project was to divide the United States into regions with grossly similar climates, geology, soils, and vegetation types. Appendix B lists the seven resulting regions. The next task involved identifying and contacting various Federal, State, and private agencies within each defined region concerning availability and access to current LRAM cost data. Appendix C summarizes the results by region and LRAM practice. Appendix F references the cost data sources. Assembling and compiling cost data represented the final task of this project.

The results of this project have applicability to all U.S. Army installations within the continental United States. The information in this report will be used by installation land managers and natural resources personnel for planning, budgeting, designing, and implementing land maintenance and rehabilitation projects. The data presented in this report should be used with caution and only as a general reference for decisionmaking. It should be noted that, without periodic update, the actual cost estimates presented in this report may not be representative for more than a few years. Relative costs between different LRAM practices should, however, remain reasonably constant. A large majority of cost references were obtained from the Internet, so land managers and other individuals may want to review the Internet during the planning and budgeting processes, as information is continually updated.

Non-SI* units of measurement used in this report can be converted to SI units as follows:

Multiply	**By**	**To Obtain**
acres	4,046.873	square meters
acres	2.457	hectares
cubic feet	0.02831685	cubic meters
cubic inches	0.00001638706	cubic meters
cubic yards	1.309	cubic meters
feet	0.3048	meters
gallons (U.S. liquid)	0.26455	liters
inches	0.0254	meters
miles (U.S. statute)	1.609347	kilometers
pounds (mass)	0.4535924	kilograms
square feet	0.09290304	square meters
square yards	1.196	square meters
tons (2,000 pounds, mass)	907.1847	kilograms
yards	0.9144	meters

* *Système International d'Unités* ("International System of Measurement"), commonly known as the "metric system."

APPENDIX B

PROJECT DETAILS AND DATA COLLECTION

For the purpose of obtaining regional cost estimates associated with LRAM practices, the United States was divided into seven regions based on gross similarities in climate, geology, soils, and vegetation types (U.S. Department of Agriculture, Natural Resources Conservation Service 1981). These seven regions and the states included in them are:

1. Pacific Coast: California, Oregon, and Washington

2. Intermountain: Arizona, Idaho, Nevada, and Utah

3. Northern Great Plains: Montana, Nebraska, North Dakota, South Dakota, and Wyoming

4. Southern Great Plains: Colorado, Kansas, New Mexico, Oklahoma, and Texas

5. Central Lake: Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin

6. Northeast: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia

7. Humid South: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

Data for Alaska was very difficult to obtain because of the state’s remoteness and diversity in climate, geology, soils, and vegetation types. Most agencies contacted indicated that adding an additional 30 to 50 percent to cost estimates for the Pacific Coast region would provide reasonable estimates for costs associated with LRAM practices in Alaska. The limited data collected from Alaskan agencies support this generalization.

Within each region, various Federal, State, and private agencies were contacted concerning their ability to provide current component cost data regarding LRAM practices. Appendix F references these data sources. Component costs refer to those associated with a specific kind of activity or task. For example, a rehabilitation and maintenance project designed to control erosion through the reestablishment of vegetation might include the following component activities: (1) earthwork to fill gullies or reduce slope length and gradient, (2) plowing or disking to prepare a seedbed for planting, (3) application of soil amendments to enhance soil fertility and subsequent plant growth, (4) drilling or broadcasting seeds on the prepared site, and (5) mulching the seeded site to protect it from further erosion while the newly seeded vegetation becomes established. Each of these five component activities has a cost associated with it; these are the types of costs presented in this report.

Unless otherwise noted, all costs in this report represent installed costs that include materials, labor, and equipment needed to satisfactorily perform the work. These costs are based on average-sized jobs done by experienced contractors, operators, and vendors. Materials costs can be reduced if local or installation resources such as riprap, gravel, straw, or plant materials are available for use. Labor and equipment costs can be reduced by using engineer troop personnel and machinery for LRAM projects whenever circumstances present this opportunity. Certain component activities, such as disking and broadcasting seed or disking and applying fertilizer, for example, can also be combined to reduce costs if conditions and project objectives permit.

All cost data were acquired from various sources between December 2003 and July 2004, with the majority obtained from the Internet. In general, only cost data from LRAM practices applied after 1 January 2000 were considered current enough to be used in this report. It is important to note that much of the data used to compile cost estimates were derived from agricultural surveys and research that may not be entirely representative of conditions encountered on Army training lands. Additional cost data were derived from state department of transportation contracts and bidding specification sheets. Significant differences between these costs, which are based on large scale, extensively managed agricultural land areas, and costs presented in publications such as Means (2004), which is based on smaller scale, intensively managed urban landscape and construction areas, should be expected. For smaller LRAM projects with limited scope, Means (2004) and A.C.E. (2004) are excellent cost-estimating resources.

Although the cost data published in this report include averages, the price ranges presented are broad enough in many cases to warrant additional consideration and are probably more useful than averages for several reasons. Site conditions can vary greatly. In some instances, difficult site conditions can increase costs, whereas ideal conditions often decrease costs. Types of equipment capable of accomplishing similar tasks also vary considerably in availability and cost of operation. Unusual circumstances affecting the amount of time required for task completion, such as extremely wet, frozen, rocky, or clayey soils, may also result in significant cost variability. Distance to job site and overall job size have dramatic effects on cost. Smaller jobs will generally have higher per unit costs than large jobs. Unionized versus nonunionized labor sources and government versus nongovernment contracts also have major impacts on cost. Fuel is generally assumed to represent an immaterial cost of a rehabilitation or maintenance project. However, the recent price increases associated with fuel costs may become a material concern in the future. Therefore, an individual may want to consult the Internet (e.g., http://tonto.eia.doe.gov/oog/info/wohdp/diesel.asp) to review current fuel costs. The cost data presented here are not meant to be all inclusive, but rather should be used with caution and only as a guide upon which to base solid decisions.

APPENDIX C

TYPES OF MAINTENANCE AND REHABILITATION ACTIVITIES

Commonly used land rehabilitation and maintenance practices can be divided into several categories depending on project objectives or the extent and severity of site degradation. These categories involve manipulating undesirable vegetation occurring on the site; manipulating physical site characteristics; installing physical or biological erosion control measures; preparing seedbeds for planting; applying soil amendments to enhance soil water retention, nutrient supplying capacity, and overall plant growth and development; establishing vegetation through direct seeding or transplanting; and safeguarding revegetation efforts (e.g., through the use of mulch) to ensure the greatest probability of successful revegetation.

Manipulating Existing Vegetation

Manipulating unwanted or undesirable vegetation is usually accomplished by applying selective or nonselective herbicides. Selective herbicides kill or damage individual species or groups of species with little or no injury to other plant species, whereas nonselective herbicides kill or damage all plant species. Both types of herbicides are manufactured in formulations (liquids, granules, pellets) that can be sprayed directly on foliage or broadcast on the soil surface using ground rigs, aircraft, or individual plant application techniques (Bovey 1977; Vallentine 1989).

Table C-1 provides regional cost estimates for the different types of herbicide application techniques. Due to differences in herbicide selectivity, mode of action, application rates, manufacturing costs, and intended use at individual sites, the price of herbicides is not included in these estimates. Appendix G, however, provides a list of the most commonly used herbicides and purchase prices associated with them. It should be noted that, due to both research and regulatory matters, new herbicides are continually coming onto the market and old ones are being pulled for various reasons. The herbicides listed are available in 2004 and are labeled for one or several of the following uses: general farmstead, fallow pasture, Conservation Reserve Program (CRP) land, and general brush control. The different brand name families of pesticides also have several different formulations with different strengths. Although

Table C-1. Regional average costs and ranges for ground and aerial application of herbicides.

		Herbicide Application Method	
Region	**Estimate Type**	**Ground Applied Herbicide* ($/acre)**	**Aerially Applied Herbicide* ($/acre)**
Pacific Coast	Average	14.28	13.50
	Range	10.00-35.00	12.00-15.00
Intermountain	Average	12.80	11.60
	Range	3.00-35.00	4.00-23.00
Northern Great Plains	Average	6.75	5.07
	Range	1.00-20.00	2.00-14.00
Southern Great Plains	Average	10.42	12.40
	Range	2.50-22.70	2.50-42.69
Central Lake	Average	9.01	7.13
	Range	2.50-31.01	4.73-10.00
Northeast	Average	7.40	8.40
	Range	5.00-9.00	7.40-10.00
Humid South	Average	12.05	5.54
	Range	2.64-30.00	3.04-8.70

* These estimates do not include the costs of herbicides. See Appendix G for a list of commonly used herbicides and their associated purchase prices.

generic brands may be available at a lower unit cost, it is important to compare active ingredients between name-brand and generic products. In addition, as the amount of chemical needed increases, the unit cost for the chemical decreases. For all regions, the low end of the cost estimate range represents ideal conditions (e.g., large acreages; dry, loamy, level soil surfaces; small stature, undesirable herbaceous plant species with modest plant densities; reduced application rates; owner-operated equipment); whereas the high end represents difficult conditions (e.g., small acreages; wet, clayey, sloping soil surfaces; large stature, undesirable woody species with high plant densities; increased application rates; contractor-owned and -operated equipment).

The Intermountain and Pacific Coast regions tended to have ground-applied average herbicide application costs that were higher when compared with other regions (Table C-1). This tendency reflects the long distances separating LRAM sites and reasonably sized population centers offering custom herbicide application in the Intermountain region, and generally higher costs of goods and services within the Pacific Coast region. The Pacific Coast and the Southern Great Plains regions tended to have higher average costs for aerial applied herbicides compared with the other regions (Table C-1). Although aerial herbicide application costs in most regions were generally lower than ground rig application costs, aerial applicators will not usually spray small, disjointed acreages that may characterize some LRAM sites.

Manipulating unwanted or undesirable vegetation can also be accomplished through mechanical practices such as bulldozing, root plowing, and brushland plowing, which are capable of damaging or destroying plant root systems (Vallentine 1989). Various tractor-mounted planes, blades, and cultivators can be used to sever the roots of trees, shrubs, and associated herbaceous perennials below ground. Root plowing, brush plowing, brush and bush hogging, and shredding are grouped under “Mechanical Brush Control” in Table C-2. These practices are best adapted to dry, level, sandy/loamy, rock-free sites having large-stature trees or shrubs in densities that make other types of mechanical treatments impractical (Carlton et al. 1973). Wet, sloping, rocky, or clayey sites and larger, more powerful tractors (D5 versus D7, for example) contribute to increased costs for all regions.

Due to increased fire frequency and severity in California in recent years, the Pacific Coast region tended to have the highest costs associated with these vegetation control practices. The higher end of the cost range represents activities that use heavy power equipment, such as root plowing, whereas the lower end of the cost range represents activities such as shredding and chopping.

Shredding, chopping, and hogging methods are usually less effective than other mechanical treatments for controlling vegetation. Repeated treatments are often necessary for reasonable control, especially on sites dominated by herbaceous perennial, sprouting, or low growing vegetation (Vallentine 1989). Increased costs can be expected on sites with steep slopes, wet soils, and vegetation types dominated by small trees or shrubs.

Table C-2. Regional average costs and ranges for manipulating vegetation with mechanical treatments and burning.

		Type of Vegetation Manipulation			
Region	**Estimate Type**	**Bulldozing ($/hr)**	**Mechanical Brush Control ($/acre)**	**Chaining ($/acre)**	**Burning ($/acre)**
Pacific Coast	Average	108.62	227.45	28.75	24.96
	Range	74.30-162.84	12.00-800.00	10.00-45.00	8.00-75.00
Inter-mountain	Average	79.17	26.40	24.67	10.02
	Range	55.00-125.00	7.00-75.00	15.00-60.00	5.00-25.00
Northern Great Plains	Average	96.06	20.83	*	9.30
	Range	13.00-160.00	2.50-59.55	*	6.00-14.00
Southern Great Plains	Average	81.56	42.67	36.55	12.49
	Range	20.00-154.00	5.00-140.00	11.00-69.00	3.80-20.00
Central Lake	Average	91.47	13.58	*	31.57
	Range	25.00-170.00	3.00-38.02	*	7.17-83.80
Northeast	Average	100.14	86.97	*	42.50
	Range	40.00-211.70	6.00-600.00	*	15.00-90.00
Humid South	Average	77.24	24.93	*	15.41
	Range	30.00-150.00	5.00-100.00	*	5.00-40.00

* Indicates data not available or not applicable.

Chaining and controlled burning are also useful for manipulating unwanted or undesirable vegetation (Scifres 1980). Chaining consists of dragging heavy anchor chain behind two tractors traveling in a parallel direction and is effective for removing even-aged, mature, nonsprouting, single-stemmed tree species. Its use is confined primarily to Pacific Coast, Intermountain, and Southern Great Plains regions where costs range from $10 to $69 per acre (Table C-2), depending on site characteristics and tree density.

Most of the costs associated with controlled burning are related to fire control (Bidwell and Masters 1993). High fuel loads, woody vegetation types, rough or dissected topography, close proximity to adjacent landowners, and strong regulatory requirements all increase controlled burning costs. In light of these considerations, it is not surprising that the Northeast has controlled burning costs well above those for other regions (Table C-2).

Manipulating Site Characteristics

Many disturbed sites require techniques specifically designed to repair gully erosion, modify slope lengths and gradients, control the direction and velocity of runoff, and trap and retain water in terraces, trenches, and furrows. Most of these techniques require some form of earthwork involving excavation, fill material, topsoil, or grading and shaping.

Table C-3 provides regional cost estimates for these types of activities. Contractor-owned equipment, remoteness of the job site, steep slopes, and wet, rocky soils contribute to increased earthwork costs. Long haul distances (greater than 300 ft) over unimproved roads with steep grades can significantly increase earthwork costs (U.S. Department of Agriculture, Forest Service 1994) beyond those indicated in Table C-3 and must be estimated for each project. Compared to other regions, excavation and fill material costs are highest for the Central Lake, Northeast, and Pacific Coast regions. Altered excavation, storage (if required), and spreading will increase the costs associated with topsoil for all regions. Specialized retrieval and storage practices are frequently necessary in the Intermountain region to salvage the limited topsoil some relatively young, arid soils have managed to develop (Buol et al. 1980) (Table C-3). Although the Southern Great Plains region tended to have the highest average grading and shaping costs, the most expensive costs associated with grading and shaping tended to occur in the Pacific Coast and Central Lake regions. Means (2004) presents more detailed information concerning estimating costs associated with different earthwork equipment and practices.

Contour terracing, trenching, and furrowing are used to intercept and control moderate amounts of runoff, thereby conserving rainfall and reducing the potential for accelerated erosion and sedimentation (Laflen et al. 1985). Terraces and trenches can be classified by alignment, cross section, grade, and outlet. They may or may not be parallel, may or may not be vegetated, may be level or on a grade, and may have surface or underground outlets, both, or neither (Laflen et al. 1985). Cost data indicate that terracing and trenching are generally more expensive in the Northeast and Pacific Coast regions (Table C-3) when compared with other regions.

Table C-3. Regional average costs and ranges for earthwork associated with manipulating site characteristics.

		Type of Earthwork					
Region	**Estimate Type**	**Excavation or Fill Material ($/cy)***	**Topsoiling ($/cy)**	**Grading and Shaping ($/acre)**	**Terracing ($/lf)***	**Furrowing ($/acre)**	**Trenching ($/lf)**
Pacific Coast	Average	4.19	21.95	321.95	0.96	12.13	5.91
	Range	1.25-12.29	17.32-30.94	50.00-1000.00	0.71-1.20	11.25-13.25	1.45-10.00
Inter-mountain	Average	2.15	4.49	205.12	0.66	16.00	1.09
	Range	1.25-4.00	2.88-6.10	50.00-435.60	0.58-0.74	12.00-20.00	0.73-1.45
Northern Great Plains	Average	2.01	2.64	327.63	0.95	17.00	1.95
	Range	1.00-8.06	1.39-10.50	225.00-600.00	0.35-1.82	12.00-22.00	0.20-3.83
Southern Great Plains	Average	3.51	2.18	339.00	0.91	11.48	1.24
	Range	1.00-22.25	0.93-3.00	178.00-500.00	0.34-5.00	3.00-21.00	0.30-4.00
Central Lake	Average	8.29	8.62	240.46	3.29	**	1.52
	Range	1.50-50.00	0.60-45.00	127.69-1120.38	0.80-8.00	**	0.50-6.73
Northeast	Average	6.95	19.03	194.38	3.31	**	3.29
	Range	0.10-41.81	1.91-95.00	100.00-300.00	0.35-5.00	**	3.00-3.57
Humid South	Average	2.70	6.14	277.70	0.92	**	1.66
	Range	1.10-12.20	2.00-15.90	75.00-600.00	0.30-1.60	**	0.50-4.43

* cy = cubic yard; lf = linear foot
** Indicates data not available or not applicable.

Contour furrowing, on the other hand, is a shallower and less disruptive soil surface manipulation than terracing and trenching. Furrows have been successfully used to control moderate amounts of runoff, improve infiltration, and increase the amount of water available for plant growth in the western United States (Vallentine 1989). It should be noted that seeding can often be combined with a shallow furrowing operation on many areas if site conditions and seasonal climatic constraints permit. Contour furrowing practices are higher in cost for the Intermountain and Northern Great Plains regions (Table C-3). Increased soil water contents, soil water depth, biomass production, rooting depth, and resultant prolonged green growth periods following rangeland furrowing are responsible for the widespread use and resultant lower costs observed in the Southern Great Plains.

Biological and Physical Erosion Control Practices

Following manipulation of existing vegetation and site characteristics, it is often desirable to install biological and physical erosion control practices that maintain site integrity prior to or concurrent with revegetation efforts. Two of the more common biological erosion control practices are grassed waterways and vegetative filter strips. *Grassed waterways* provide an energy dissipating vegetative mat over which deliberately concentrated runoff can flow without causing excessive erosion (Laflen et al. 1985). Grassed waterway costs include associated earthwork (grading/shaping), seedbed preparation, soil amendments, and seed from species adapted for this purpose. Regions with higher average annual precipitation and greater probability for high intensity precipitation events, such as the Central Lake, Northeast, and Humid South regions generally have increased grassed waterway costs (Table C-4). Higher costs can be expected on remote sites with steep slopes and unfavorable soil conditions (e.g., wet, clayey, or rocky). Cost ranges shown in Table C-4 illustrate this variability due to adverse site characteristics and remoteness.

Table C-4. Regional average costs and ranges for biological erosion control practices.

		Type of Practice	
Region	**Estimate Type**	**Grassed Waterways ($/acre)**	**Filter Stripping ($/acre)**
Pacific Coast	Average	866.67	112.20
	Range	100.00-2000.00	12.00-300.00
Intermountain	Average	925.00	78.33
	Range	350.00-1500.00	5.00-200.00
Northern Great Plains	Average	1278.38	42.33
	Range	500.00-2600.00	20.00-75.00
Southern Great Plains	Average	504.57	73.33
	Range	150.00-750.00	10.00-110.00
Central Lake	Average	1438.50	95.33
	Range	377.00-2500.00	12.00-175.00
Northeast	Average	1437.50	272.95
	Range	600.00-2750.00	12.00-600.00
Humid South	Average	1721.24	172.78
	Range	943.00-2878.33	60.30-455.00

Vegetative filter stripping with annual or perennial species that have the ability to quickly germinate and subsequently develop extensive root systems offers a means to slow runoff velocity and trap suspended sediment behind the upslope side of vegetation strips. Filter stripping costs include seedbed preparation and seed. Increased costs can be expected on longer, steeper, or more unstable slopes that require strips to be planted closer together for effectiveness. This increased cost is especially true for regions prone to high intensity rainfall such as the Northeast and Humid South (Table C-4).

Physical erosion control practices include diversion ditches, sediment retention ponds, gabions, riprap, and sediment fencing. All of these practices are directed towards diverting runoff to, or concentrating flow on, areas less prone to erosion, reducing runoff volumes and velocities, or trapping suspended sediments before they move off-site (Laflen et al. 1985). Installation costs for diversions and sediment retention ponds were higher in the Pacific Coast than in other regions (Table C-5). The Central Lake region had the highest average cost for installing gabions, the Northeast had the highest average cost for riprap, and the Northern Great Plains had the highest average cost for

Table C-5. Regional average costs and ranges for physical erosion control practices.

		Type of Practice				
Region	**Estimate Type**	**Diversion Ditches ($/lf)***	**Sediment Retention Ponds ($/cy)***	**Gabions ($/cy)**	**Riprap ($/cy)**	**Sediment Fence ($/lf)**
Pacific Coast	Average	5.94	11.98	122.50	33.15	2.19
	Range	1.20-20.00	4.00-24.80	100.00-145.00	23.33-61.61	1.15-3.98
Inter-mountain	Average	2.07	2.57	130.00	36.67	3.15
	Range	0.50-4.00	0.98-6.00	85.00-240.00	20.00-50.00	2.08-3.74
Northern Great Plains	Average	1.34	2.01	128.06	36.05	3.70
	Range	1.00-2.70	1.00-8.06	71.41-157.50	11.00-65.19	0.34-10.00
Southern Great Plains	Average	1.24	5.49	135.77	44.71	2.91
	Range	0.30-4.00	1.00-13.00	62.30-215.00	22.25-80.00	1.00-3.58
Central Lake	Average	2.86	3.39	141.30	36.76	1.73
	Range	1.25-4.50	1.00-10.00	130.78-160.00	10.71-141.65	0.63-4.00
Northeast	Average	4.06	4.13	117.50	46.37	2.30
	Range	1.50-10.00	2.00-14.40	110.00-125.00	13.30-100.00	0.60-10.00
Humid South	Average	1.93	4.92	117.11	26.95	2.02
	Range	0.73-5.30	1.65-14.05	86.61-150.00	10.65-87.50	1.00-5.00
* cy = cubic yard; lf = linear foot						

installing sediment fence (Table C-5). Data regarding physical erosion control materials and structures such as cabled and tri-lock blocks, flumes, chutes, and culverts are not presented due to their cost variability. The costs associated with these materials and structures are probably best approached on a project-specific basis using vendor, contractor, or engineering specifications.

Seedbed Preparation

Choosing a seedbed preparation method depends on several site-specific criteria including slope, kinds and amounts of existing vegetation, and soil type, depth, texture, chemistry, and stoniness (Vallentine 1989). More common methods involve using fire, herbicides, and mechanical farming implements. Fire and herbicidal methods use direct seeding into vegetation that has been recently burned or sprayed. These methods are often lower in cost than mechanical seedbed preparation; however, they have distinct disadvantages that preclude their widespread use. Heterogeneous burns due to insufficient fuel loads, competitive vegetation that sprouts in response to fire, and potential soil crusting problems limit the applicability and success of fire as a seedbed preparation tool (Vallentine 1989). Lack of complete kill, residue toxicity, or excessive dead mulch and litter from sprayed vegetation may subject newly planted seedlings to herbicide stress and undue competition for light, nutrients, and water that can result in seeding failure. If the above disadvantages can be overcome, fire and herbicides are effective seedbed preparation methods. Regional cost estimates associated with these methods are presented in Tables C-1 and C-2.

Seedbed preparation methods involving mechanical farming implements include subsoiling, chiseling, moldboard plowing, offset disking, and tandem disking. Subsoiling and chiseling are deep tillage operations designed to break or shatter compacted soil layers that can inhibit germination, root development, and moisture infiltration (Brady 1980). Chiseling is less expensive than subsoiling due to shallower depths of implement operation and reduced power requirements. Regional cost estimates for subsoiling and chiseling are shown in Table C-6. Wet, rocky soils, steeper slopes, and greater depths of subsoiling or chiseling necessary to break up compacted soil layers contribute to increased costs. The generally higher costs of goods and services in the Pacific Coast and Northeast resulted in higher average costs for subsoiling and chiseling in these regions compared with the other regions (Table C-6). Moldboard plowing, offset disking, and tandem disking are

Table C-6. Regional average costs and ranges for seedbed preparation practices.

		Types of Seedbed Preparation				
Region	**Estimate Type**	**Subsoiling ($/acre)**	**Chiseling ($/acre)**	**Moldboard Plowing ($/acre)**	**Offset Disking ($/acre)**	**Tandem Disking ($/acre)**
Pacific Coast	Average	39.00	23.88	*	17.00	18.46
	Range	20.00-75.00	10.00-50.00	*	14.00-25.00	7.00-24.51
Inter-mountain	Average	18.18	14.13	16.35	11.01	9.63
	Range	12.00-22.00	5.00-30.00	7.00-28.00	8.00-15.00	3.27-20.00
Northern Great Plains	Average	18.18	10.50	14.51	12.43	9.63
	Range	4.00-55.00	3.00-20.00	2.75-38.00	2.00-55.00	2.00-45.00
Southern Great Plains	Average	12.12	9.47	12.23	7.11	10.55
	Range	4.00-30.00	3.50-21.00	5.00-16.00	4.00-15.00	3.00-25.00
Central Lake	Average	13.49	10.88	14.20	11.06	9.15
	Range	7.00-25.00	5.00-30.00	6.00-30.00	6.00-30.00	4.00-25.00
Northeast	Average	22.10	14.73	15.18	12.32	11.63
	Range	5.55-50.00	4.32-37.00	7.50-20.50	4.00-20.00	3.00-25.00
Humid South	Average	21.50	11.68	14.21	12.47	12.00
	Range	7.43-85.00	2.50-37.00	5.00-40.00	6.26-30.00	2.00-35.00

* Indicates data not available or not applicable.

shallower tillage operations that can be used alone or in combination with subsoiling or chiseling, depending on site characteristics. All three practices are capable of reducing or eliminating existing vegetation and seed supplies of undesirable competing species while providing conditions conducive to seed germination and plant establishment (Vallentine 1989). Moldboard plowing has the greatest power requirements and is, therefore, more expensive than offset or tandem disking (Table C-6). Moldboard plows are ineffective on hard, rocky, or clayey soils, making them far less versatile than offset or tandem disks, which are better adapted to unfavorable soil and vegetative conditions associated with noncultivated sites. For these reasons, moldboard plowing rarely occurs in the Pacific Coast region; therefore, cost data for this particular type of operation were not available. The Intermountain region, characterized by long distances to LRAM sites and reduced equipment availability associated with small population centers, had the highest average cost for moldboard plowing compared with other regions. Offset disking is generally more expensive than tandem disking (Table C-6), but does a better job of killing and mulching existing vegetation with one pass of the implement (Vallentine 1989). As with subsoiling and chiseling, higher costs for offset and tandem disking were observed for the Pacific Coast region (Table C-6). Well-developed farming enterprises in the Southern Great Plains, Northern Great Plains, and Central Lake regions with greater equipment availability generally result in lower mechanical seedbed preparation costs when compared to other regions (Table C-6).

Soil Amendments

Normal plant growth depends on the nutrient-supplying capacity of soil to support and maintain critical physiological functions. Disturbed, degraded, and eroded soils are frequently lower in organic matter and other essential nutrients than their undisturbed counterparts (Aguilar et al. 1988; Davidson and Ackerman 1993) and usually require the addition of supplemental fertilizer to encourage and sustain plant growth. Soil tests should be used to determine the kinds and amounts of nutrients that need to be added to the soil through fertilization.

Regional cost estimates for broadcasting and banding fertilizer are given in Table C-7. Because each LRAM site will have different fertilizer requirements, the price of fertilizers is not included in these estimates. Local feed and seed dealers or U.S. Department of Agriculture, Natural Resources Conservation Services personnel can provide up-to-date fertilizer price information based on site-specific soil test recommendations.

Broadcasting fertilizer on the soil surface is the most widely used application technique. It is less expensive than banding, which involves placing narrow, continuous bands of fertilizer below the soil surface (Table C-7). Although banding is a more expensive technique, it can reduce phosphorus fertilizer costs because it reduces fertilizer surface areas exposed to the soil, thereby proportionally reducing the amount that becomes essentially unavailable for plant uptake through fixation on soil colloids (Alexander 1977; Brady 1980). In general, the high end of the range can be used as an estimate for banding fertilizer costs and the low end of the range can be used as an estimate for broadcasting fertilizer. Broadcasting and banding costs, like those associated with seedbed preparation, were highest in the Pacific Coast region. The highly established farming enterprises in the Southern and Northern Great Plains regions result in lower costs for these operations compared with other regions. The costs of these procedures vary depending on job size, application rates, slope steepness, and soil moisture content and rockiness (Table C-7).

Table C-7. Regional average costs and ranges for soil amendment application.

		Types of Amendments		
Region	**Estimate Type**	**Fertilizer, Broadcasted, or Banded ($/acre)**	**Limestone and Gypsum* ($/acre)**	**Nontraditional Materials** ($)**
Pacific Coast	Average	13.65	28.99	44.80/acre
	Range	5.00-32.00	5.00-75.00	12.00-100.00/acre
Inter-mountain	Average	7.11	40.56	9.05/acre
	Range	3.50-12.00	3.50-75.00	1.75-18.00/acre
Northern Great Plains	Average	4.35	336.47	60.42/hour
	Range	0.50-25.00	225.88-498.30	6.00-175.00/hour
Southern Great Plains	Average	6.47	23.55	4.62/ton
	Range	1.00-28.00	2.00-60.00	1.60-7.75/ton
Central Lake	Average	6.90	19.73	82.97/hour
	Range	1.00-35.00	2.00-90.00	35.00-156.61/hour
Northeast	Average	6.66	35.80	38.46/hour
	Range	2.57-10.00	5.00-100.00	10.00-90.00/hour
Humid South	Average	6.69	51.27	27.83/hour
	Range	2.50-25.00	3.00-195.00	7.75-45.00/hour

* Within regions, the lower end of the cost range excludes amendment costs, whereas the higher end apparently includes amendment costs. For the Northern Great Plains, however, the entire price range appears to include amendment costs.
** These may include municipal sludge, papermill wastes, compost, poultry litter, livestock manure, and food manufacturing wastes.

Extreme soil acidity or alkalinity have adverse effects on seed germination and plant growth. Correcting these problems is often accomplished by applying agricultural lime to acid soils and gypsum or sulfur to alkaline soils (Brady 1980). Soil tests should be used to determine the kinds and amounts of amendments needed to correct acidity and alkalinity problems.

Table C-7 also provides regional cost estimates for applying amendments necessary to adjust soil pH. Variability of the site-specific conditions leads to distinctions in the kinds and amounts of lime, gypsum, or sulfur needed to correct a given problem. The low end of the cost range excludes amendment costs, and thus consists only of the labor and equipment associated with the application. However, the significantly higher costs obtained for the Northern Great Plains compared with the other regions appears to include the cost of the materials and custom application. The Humid South, where soil acidity problems are common, tends to have greater costs for applying lime compared with other regions.

Depending on region and proximity to various production, manufacturing, or processing facilities, various sources of nontraditional soil amendments may be available that can complement or reduce the amounts of commercially produced fertilizer required to build soil fertility. These amendments include papermill wastes, municipal sludge, compost, poultry litter, livestock manures, and food processing wastes. Amendments can be a valuable contribution to most LRAM projects, and their availability and use should be thoroughly explored. In addition to supplying soil nutrients, many of these soil amendments can also build soil organic matter, improve soil aggregate stability and resistance to erosion, and increase water holding capacity (Sharpley et al. 1993; Campbell et al. 1994; Feagley et al. 1994; Pichtel et al. 1994). Table C-7 provides some very limited data concerning regional cost estimates associated with nontraditional soil amendments. It should be noted that the cost data were obtained in various units (e.g., acres, hours, tons). Based on the costs obtained, it is assumed that these costs include the amendment and its loading, transportation, and subsequent spreading. Because of the extreme variability in nontraditional amendment type, source, availability, and desirability, these costs are rough approximations only and should not be used in any formal project cost-estimating activity.

Revegetation

Rapid reestablishment of a vegetative ground cover is paramount in many LRAM projects to maintain site integrity and prevent further erosion. Re-establishing vegetation can be accomplished through direct seeding, hydroseeding, or transplanting of species adapted to general climatic and edaphic conditions of the site. Direct seeding techniques include drill seeding, hydroseeding, and broadcasting seed onto soil surfaces using ground equipment or aircraft. In the past, it was recommended that, if possible, drill seeding should always take place in prepared seedbeds. However, the emergence of “no-till” drill seeders capable of planting on “nonprepared” seedbeds with favorable yields renders the prior recommendation obsolete. Nevertheless, broadcasting seed should be considered only in situations where there is some assurance that sown seeds can be covered with soil to increase the probability of successful revegetation (Vallentine 1989).

Drill seeding uniformly distributes and covers seed at the proper planting depth in a single farming operation, resulting in enhanced germination, establishment, and stand uniformity when compared with broadcasting and hydroseeding. Broadcasting and hydroseeding may, however, be the only means of seeding on remote or inaccessible sites where rough terrain, steep slopes, and wet or rocky soils make seedbed preparation and drill seeding impractical. Table C-8 provides regional cost estimates for drill seeding, hydroseeding, and broadcasting seed with ground equipment and aircraft. Due to regional differences in species adaptability and availability, the price of seed is not included in cost estimates for drill seeding and broadcasting. Cost estimates for hydroseeding, on the other hand, include the price of regionally adapted seed, starter fertilizer, and mulch.

Table C-8. Regional average costs and ranges for revegetation using direct seeding methods.

		Types of Direct Seeding Methods			
Region	**Estimate Type**	**Drill Seeding ($/acre)**	**Broadcast Seeding ($/acre)**	**Aerial Seeding ($/acre)**	**Hydroseeding ($/acre)**
Pacific Coast	Average	16.06	9.50	19.87	1930.00
	Range	10.00-25.00	6.00-15.00	15.00-26.64	1500.00-2360.00
Inter-mountain	Average	12.49	6.75	21.25	1136.10
	Range	5.00-25.00	6.00-8.00	14.00-30.00	697.00-2360.00
Northern Great Plains	Average	11.05	4.91	21.17	2008.60
	Range	3.00-20.00	3.75-7.47	5.00-30.00	774.40-5808.00
Southern Great Plains	Average	9.24	6.13	14.66	1308.21
	Range	3.00-20.00	3.00-10.00	3.00-23.68	600.00-6534.00
Central Lake	Average	12.47	6.67	8.51	1143.24
	Range	5.00-25.00	2.00-18.00	4.50-12.29	600.00-3485.00
Northeast	Average	12.17	8.00	17.25	2037.28
	Range	3.00-18.00	2.50-11.00	12.00-33.00	1913.00-2613.60
Humid South	Average	10.80	8.55	9.00	1314.25
	Range	4.00-16.67	6.00-12.00	6.00-12.00	756.98-2000.00

Drill seeding costs were highest in the Pacific Coast and Intermountain regions where the more unfavorable site conditions associated with rangeland revegetation projects result in increased prices (Table C-8). Conversely, drill seeding costs were lowest in the Southern Great Plains region where favorable site conditions associated with production agriculture result in lower prices. Broadcast seeding costs were highest in the Pacific Coast due to generally higher costs of goods and services. Aerial seeding costs were highest in the Intermountain region due to long distances to LRAM sites. Uneven seed distribution and poorer germination responses associated with either form of broadcasting often require increased seeding rates compared to drill seeding. Although hydroseeding is extremely expensive and should be restricted to LRAM sites for which no other alternatives exist, the price of hydroseeding has dropped in price the last 10 years as more hydroseeding companies enter the marketplace (Table C-8).

Table C-9. Regional average costs and ranges for revegetation using transplants.

		Types of Plant Materials Available for Transplanting			
Region	**Estimate Type**	**Trees and Shrubs, Bare Root ($/plant)**	**Trees and Shrubs, Containerized ($/plant)**	**Grass Sods ($/sy)***	**Grass Stolons and Rhizomes ($/acre)**
Pacific Coast	Average	0.98	3.55	3.09	**
	Range	0.17-2.00	0.18-12.03	1.35-5.60	**
Inter mountain	Average	1.70	6.40	2.48	**
	Range	0.24-4.00	0.82-15.00	1.35-3.60	**
Northern Great Plains	Average	1.50	3.28	4.50	**
	Range	0.19-3.31	0.70-10.50	1.00-9.18	**
Southern Great Plains	Average	1.06	5.49	4.04	86.88
	Range	0.55-1.60	1.05-15.00	3.09-4.90	45.00-200.00
Central Lake	Average	0.78	5.35	4.65	**
	Range	0.04-10.00	0.55-12.77	2.38-10.25	**
Northeast	Average	0.73	0.78	2.85	**
	Range	0.04-1.41	0.17-1.41	1.98-4.86	**
Humid South	Average	0.22	1.71	3.83	77.25
	Range	0.03-0.95	0.07-13.45	1.16-7.74	42.00-150.00

* sy = square yard
** Indicates data not available or not applicable

Under special circumstances or within some vegetation types, it may be desirable to transplant vegetation rather than establish it from seed. This is especially true for many shrubs and trees that, because of their highly specific germination requirements and/or slow growth characteristics, probably would not or could not establish from seed on many LRAM sites.

Cost estimates for transplanting bare root and containerized tree and shrub saplings/seedlings vary significantly within and between regions (Table C-9) depending on species, growth and maintenance requirements, age, and size. It should be noted that, for many species, costs can significantly exceed those presented in Table C-9 and reliable estimates should be based on site-specific recommendations and requirements. Desirable, intensively managed, greenhouse grown species with exacting germination and growth requirements will be more expensive to purchase and transplant than fast-growing species raised in outdoor flats. Containerized plants, regardless of species, age, or size, will be more expensive than bare root counterparts (Table C-9) due to increased survivability following transplantation (Utah Agricultural Experiment Station 1979; Blauer et al. 1993) and the ease with which they can be transported, handled, and mechanically planted. Transplanting the very limited selection of trees and shrubs adapted to the arid/semiarid Intermountain region (Blauer et al. 1993) results in the highest average costs compared to other regions (Table C-9) because water is usually applied to individual plants following transplanting to increase chances for long-term survival (Pendleton et al. 1992). Under exceptionally arid conditions, irrigating plants for several weeks after transplanting may be essential for plant survival (Utah Agricultural Experiment Station 1979). Conversely, the greater selection of trees and shrubs adapted to Northeast, Humid South, and Central Lake regions, where water application following transplanting is usually not required for survival, generally results in lower costs.

Grass stolons, rhizomes, or sod are occasionally transplanted in place of seeding to establish vegetation on disturbed sites. Bermudagrass [*Cynodon dactylon(L.)* Pers.] is the most common grass established by this method (Burton and Hanna 1985) and is used primarily in the Southern Great Plains and Humid South regions (Table C-9). Other rhizomatous and stoloniferous grasses can be of local importance but cost estimates for transplanting them are not readily available. Grass sod is frequently used in small urban landscaping projects where anticipated benefits outweigh transplanting costs. On larger

LRAM projects that will be less intensively managed, grass sod transplanting costs are probably prohibitive except under very specific circumstances. These grass transplanting options are all significantly more expensive than seeding (Tables C-8 and C-9) and should be restricted to sites where no viable alternatives exist.

Safeguards for Revegetation Success

Immediately following a revegetation effort, surface mulching is often needed to protect the site from further erosion until recently seeded or transplanted vegetation becomes established. Surface mulches can impede runoff and erosion, increase available soil water, lower soil temperatures, reduce evaporation, and conserve moisture available to plant roots (Hungerford and Babbitt 1987). Straw or hay, generally applied at a rate of 2 tons/acre, is the most common surface mulching practice. To ensure that mulches remain on recently revegetated areas, application is usually followed by disking or crimping the mulch into the soil surface with various farm implements to prevent mass movement (Utah Agricultural Experiment Station 1979). Under extreme conditions, fabrics and netting stapled over mulches are used to hold it in place. Regional cost estimates for mulching and fabrics/netting are shown in Table C-10. The cost of fabrics and netting are presented separately and should be added to the cost of the mulch and its application (Table C-10). Costs vary depending on mulch availability and slope steepness, which affects equipment selection and application method (blower versus hand application).

Various chemical tackifiers are also used in place of disking, crimping, fabrics, and netting to hold mulches in place. However, these costs are generally significantly higher than those associated with mulching followed by disking (data not shown).

Gravel can also be used as a mulching material, although it is more frequently used as a deep, permanent mulch that prevents plant growth or as an erosion control material. Thin layers of gravel are effective for controlling wind erosion on highly susceptible revegetated sites due to increased soil surface coverage and roughness (Fryrear and Bilbro 1994). Provided the gravel layer is not thick and continuous, plant germination and establishment should not be compromised. Table C-10 provides regional cost estimates for gravel. Remoteness of the job site, proximity to quarries, and gravel size contribute to price variability. Generally, gravel is too expensive for use on large revegetated areas requiring mulching for enhanced plant establishment, water conservation, and wind erosion control. Therefore, other alternatives should be investigated.

Table C-10. Regional average costs and ranges for materials to safeguard revegetation success.

		Types of Safeguarding Materials		
Region	**Estimate Type**	**Straw/Hay Mulch ($/acre)**	**Gravel Mulch ($/cy)***	**Fabrics and Netting ($/sy)****
Pacific Coast	Average	412.03	16.23	1.64
	Range	20.00-2176.19	8.00-20.00	0.90-2.25
Inter mountain	Average	304.00	19.33	3.55
	Range	23.00-1450.00	18.00-20.00	1.25-7.65
Northern Great Plains	Average	666.66	23.48	2.09
	Range	25.00-4263.00	10.00-40.00	0.50-5.78
Southern Great Plains	Average	426.98	18.50	1.32
	Range	115.00-1100.00	12.00-25.00	0.60-3.95
Central Lake	Average	610.62	25.07	1.78
	Range	197.75-1936.00	18.00-28.94	0.53-5.00
Northeast	Average	845.93	15.46	3.05
	Range	200.00-3190.00	5.00-85.00	0.60-5.00
Humid South	Average	390.95	18.78	2.29
	Range	19.66-2000.00	6.00-61.80	0.36-6.75

* cy = cubic yard
** sy = square yard

APPENDIX D

SUMMARY

This report provides current, regionally based cost estimates for component activities associated with rehabilitation and maintenance of Army training lands. Data used to prepare these estimates were obtained from numerous Federal, State, and private agencies involved in similar types of activities. Although exceptions were numerous, land rehabilitation and maintenance costs are generally higher within Pacific Coast, Northeast, and Intermountain regions. This is a reflection of the higher costs of goods and services in Pacific Coast and Northeast regions, and greater distances to job sites coupled with reduced equipment availability and generally poorer soil conditions in the Intermountain region. Lowest land rehabilitation and maintenance costs were generally observed within Northern Great Plains, Southern Great Plains, and Central Lake regions. Well-developed agricultural production enterprises within these regions result in greater equipment availability, higher proportions of experienced, agriculturally oriented contractors and vendors, and reduced costs.

Land rehabilitation and maintenance costs can and do vary significantly within and between regions due to differences in climate, geology, soils, vegetation types, remoteness of job sites, project size, skilled labor sources, contract types, and equipment availability and ownership. Therefore, data in this report should be used with caution and only as a general reference for decisionmaking. Actual cost estimates presented in this report will change with time and may require periodic update to remain current. Relative costs, the ratio of prices between similar types of activities (e.g., drill seeding versus broadcast seeding), should, however, remain relatively constant over time, ensuring their future applicability.

APPENDIX E

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APPENDIX F

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APPENDIX G

APPROXIMATE RETAIL PRICES OF COMMON HERBICIDES

Brand Name	Active Ingredient(s)	Res.*	Manuf.	Use	Average $ Price	Unit
2-4D Amine	2-4D		various	to control broadleaf weeds	14.90	gal
Aatrex 4L	Atrazine	R	Syngenta	able to use on roadsides in certain states	12.22	gal
Ally	Metsulfuron Methyl		Dupont	use on wheat barley and fallow pastures	24.01	oz
Buctril	bromonxynil		Bayer	use on sod and crp and other grain crops	75.07	gal
Clarity	Diglycolamine		BASF	general farmstead	97.90	gal
Fusion/Fusilade	fluazifop-P-butyl		Syngenta	postemergence control of grass - labeled for rights of way	145.92	gal
Gramoxone	paraquat	R	Syngenta	general farmstead	43.60	gal
Harmony	thifensulfuron-methyl + metsulfuron-methyl		Dupont	use on wheat barley and fallow pastures	13.45	oz
Hyvar	Bromacil		Dupont	brush control	71.55	gal
Poast	Sethoxydim		Microflow	use in listed field crops (fallow crp is listed)	70.56	gal
Redeem	triclopyr		Dow	control annual and perennial broadleaf weeds	95.16	gal
Rely	glufosinate-ammonium		Bayer	general farmstead and listed crops	72.00	gal
Roundup	glyphosate		Monsanto	general farmstead	50.92	gal
Sahara	imazapyr		BASF	bare ground vegetation control	12.31	lb
Snapshot	isoxaben + oryzalin		Dow	control of certain annual grasses and broadleaf	1.81	lb
Spike	tebuthiuron		Dow	woody plant control	19.14	lb
Stinger	clopyralid		Dow	postemergence control of broadleaf in crp and fallow	538.13	gal
Tordon	picloram and 2,4-D	R	Dow	control of weeds, brush and woody plants	56.86	gal
Treflan	trifluralin		Dow	preemergence control of annual grasses and broadleaf weeds	22.17	gal
Weedone	dichlorprop		Nufarm	control broadleaf	22.24	gal
Weedtrine	diquat dibromide		App. Bio.	use in still lakes, ponds, ditches	45.98	gal

* "R" indicates a restricted use pesticide in which a license must be obtained to use or buy this product; restrictions vary from State to State.